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GAS DISCHARGES

On Exponential Growth

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At an early point in his career Pedersen published a paper on breakdown calculations [1]. The approach he employed led him to believe that he had unearthed the philosopher's stone. In later years, once he had appreciated fully the real nature of exponential growth, Pedersen considered this early work to be but a youthful folly.

Thereafter, he took pains to highlight both the exponential nature of discharge growth and the implications of such on discharge modeling in relation to breakdown calculations. In this way, he came to adopt an Occam's razor [2-5] approach to onset calculations. Occam's razor, which is a concept in philosophy, may be defined as the principle of simplest possible assumptions, and on this basis only the features of discharge growth essential to the problem at hand should be taken into account. For discharge onset calculations, such an approach leads one naturally to the streamer criterion [6].

Pedersen returned to the nature of exponential growth in his 1989 Whitehead Memorial Lecture, and to illustrate his point of view he produced several memorable overheads. As these were not incorporated in the published version of the Lecture [7], one of the overheads is presented here as a reminder of the particular care which he always exercised over the format of, and the information contained in, the slides/overheads employed at oral presentations.

The agreement obtained between measured breakdown voltages and predicted breakdown values is frequently used as a means of assessing the validity of the theory/model in question. However, owing to the mathematical nature of exponential growth, it is in fact far too easy to formulate a criterion which provides acceptable breakdown values, although the criterion may contain totally unrealistic features. The literature on breakdown calculations contains some striking examples of this characteristic.

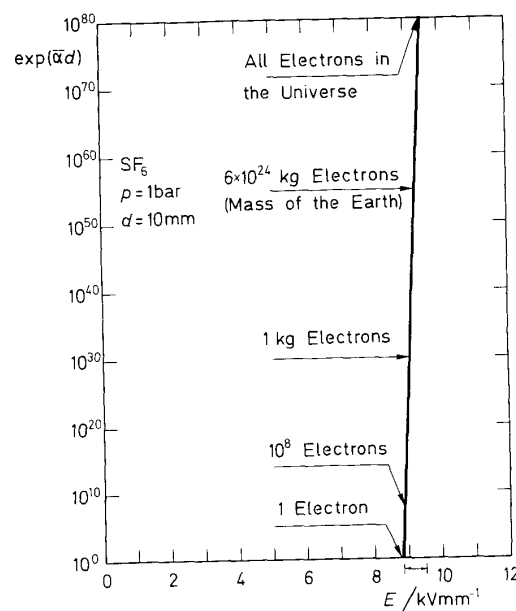


Figure 1.
Unrestricted exponential growth in SF₆.

To highlight the insensitivity of breakdown voltages with respect to modeling, Pedersen produced Figure 1. In this Figure the variation of $\exp(\bar{\alpha}d)$ with field strength E is shown for SF₆ at 0.1 MPa, for a uniform field gap of length $d = 10$ mm. $\bar{\alpha}$ is the effective coefficient of ionization. Figure 1 illustrates that an increase in E of only 7.6% results in an 80 orders of magnitude increase in the value of $\exp(\bar{\alpha}d)$.

The purpose of this rather facetious diagram is to underline that, as all onset criteria effectively embody such an exponential term, lack of agreement between theory and experiment should be virtually impossible. Never-

theless, if a critical assessment is not exercised on the resulting numerical data, absurd physical situations may easily arise. On the other hand, satisfactory numerical breakdown data would not necessarily imply either the indispensability or correctness of a sophisticated gas-physical process incorporated in the breakdown model, unless some novel detail was predicted or confirmed. To put things more succinctly, one could underline the numerical dangers involved with exponential growth through the following lighthearted remark: "SF₆ and the numbers racket".

REFERENCES

- [1] A. Pedersen, "Calculation of Spark Breakdown Voltages in Air at Atmospheric Pressure", *Applied Scientific Research*, Vol. B1, pp. 299-305, 1949.
- [2] William of Occam/Ockham (1280-1349), "Entia non sunt multiplicanda praeter necessitatem" quoted in G. H. von Wright, *Logik, filosofi och språk*, Bokförlagrt Aldus/Bonniers Stockholm 1965.
- [3] B. Russell, *History of Western Philosophy*, George Allen and Unwin Ltd. London 1946.
- [4] *The New Encyclopaedia Britannica-Macropaedia*, Encyclopaedia Britannica Inc. Chicago, Vol. VII, pp. 475-476, 1974.
- [5] *The New Encyclopaedia Britannica-Micropaedia*, Encyclopaedia Britannica Inc. Chicago, Vol. 13, pp. 504-505, 1974.
- [6] A. Pedersen, I. W. McAllister, G. C. Crichton and S. Vibholm, "Formulation of the Streamer Breakdown Criterion and its Application to Strongly Electronegative Gases and Gas Mixtures", *Archiv für Elektrotechnik*, Vol. 67, pp. 395-402, 1984.
- [7] A. Pedersen, "On the Electrical Breakdown of Gaseous Dielectrics. An Engineering Approach", *IEEE Trans. Elect. Insul.*, Vol. 24, pp. 721-739, 1989.

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